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Article

Very Low Birth Weight Births At Non-NICU Hospitals: The Role of Sociodemographic, Perinatal, and Geographic Factors

Jeffrey B. Gould, MD, MPH

Rhonda Sarnoff, MSPH

Hao Liu, MA

David R. Bell, MSW

Gilberto Chavez, MD, MPH

PURPOSE:

The purpose of this study was to assess the extent of variation in the percentage of very low birth weight (VLBW) infants born at perinatal Level I hospitals (no Neonatal Intensive Care Unit [NICU]) across California's nine geographic regions. The role of sociodemographic, perinatal, and geographic factors was also assessed.

METHODS:

Multivariate analysis of California birth certificate files between 1989 and 1993, for 24,094 born infants weighing between 500 and 1499 gm, was conducted to identify factors associated with delivery at a level I hospital. Analyses specific for race and ethnicity were also conducted for Hispanic, African American, and white cohorts.

RESULTS:

In the 5-year study period, 1989 through 1993, 10.5% (2,409) of live-born VLBW infants were delivered in Level I hospitals. Significant variation across regions was evident, ranging from 3.1% to a high of 24.3%. After controlling for multiple factors, the odds of delivering at a level I hospital were decreased for African American- and South East Asians and increased in Hispanic women as compared with white non-Hispanic women. For all women, less than adequate prenatal care, living in a 50% to 75% urban zip code, and living greater than 25 miles from the nearest NICU significantly increased the odds of VLBW delivery at a Level I hospital. For Hispanics, teen pregnancy and having two or more prior infant deaths increased the odds, whereas Medi-Cal as the payer source for delivery and two or more pregnancy complications decreased the odds of a Level I VLBW delivery. After taking these factors into account, when compared with Los Angeles, the odds of inappropriate delivery site ranged from 0.37 to 2.75 across California's nine geographic perinatal regions. Of this variation, 78% could be accounted for by the percentage of total births that delivered at a region's Level I hospitals.

CONCLUSION:

The overall state average of 10% deliveries of VLBW at Level I hospitals, although close to the Healthy People 2000 objective for the year 2000 did not indicate a wide variation across California's nine geographic regions. Risk adjustment for differences in the likelihood of inappropriate site for the high risk VLBW infants suggest that reaching the Healthy People 2000 objective will require further strengthening of California's perinatal regional networks, especially in those regions with a high percentage of total births delivered at Level I hospitals.

Advances in neonatal technology have made possible significant reductions in mortality and morbidity among very low birth weight (VLBW) infants who weigh between 500 and 1499 gm. Studies have found a relationship between the level of a hospital's neonatal services and its mortality rates for low and VLBW newborns. In recognition of the importance of adequate hospital facilities to the health and survival of high-risk infants, the Healthy People 2000 objectives of 1990 included assuring that at least 90% of pregnant women and infants receive risk-appropriate care, as assessed by the proportion of VLBW infants born in facilities with 24-hour coverage by a neonatologist.

To improve access to the appropriate level of obstetric and neonatal care, states began to regionalize perinatal services in the 1970s. **Regionalization includes two principal strategies to improve access to appropriate care. The first is the provision of comprehensive risk assessment of pregnant women. The second is the development of coordinated referral and transport systems to facilitate movement of patients across levels of care within a geographically-based network of hospitals providing a range of levels of care.**

The growth of more market-driven health services since the 1980s, including the dramatic expansion of for-profit managed care companies, has led to growing concerns about the weakening of perinatal networks. As patients' choice of hospital is constrained by third-party payers in **competitive health care markets, the pressure to use lower level hospitals for deliveries may increase.** One possible consequence could be reflected in the number of VLBW infants born in hospitals without a neonatal intensive care facility (NICU).

The reasons for why delivery of VLBW infants occurs at hospitals that do not have a NICU (Level I) are not well understood and could be quite different across various states. In a recent publication, Bronstein et al. ¹⁴ examined the relationship of maternal race, insurance

School of Public Health (J. B. G., R. S. H. L., D. R. B.), University of California at Berkeley, and Epidemiology and Evaluation Section (G. C.), Maternal and Child Health Branch, California Department of Health Services, Sacramento, CA.

Address correspondence and reprint requests to Jeffrey B. Gould, MD, MPH, University of California, Berkeley School of Public Health, 309 Earl Warren Hall, 7360 Berkeley, CA 94720-7360.

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coverage, and trimester of **prenatal care initiation to place of delivery** of VLBW infants in Alabama from 1988 to 1990. That investigation found an increased likelihood of delivering at a hospital with no NICU in mothers who had not received first trimester care, had not finished high school, were less than 18 years of age, or lived far from a hospital with a NICU. They also identified racial differences. For white women, early prenatal care combined with Medicaid insurance increased the likelihood of an appropriate VLBW delivery site. For nonwhite women, early prenatal care was associated with NICU delivery regardless of payer source.

The purpose of our analysis was to identify predictors of the delivery of VLBW newborns in Level I facilities and to identify differences in the extent of Level I VLBW births across California's nine geographic perinatal regions during the period 1989 through 1993. **The identification** of factors associated with the delivery of VLBW infants at Level I hospitals has the potential of facilitating improved referral of at-risk women to hospitals with appropriate levels of perinatal care. it can also potentially identify systems factors that obstruct access to medically appropriate care.

MATERLUS AND METHODS

The analysis was based on data **from the California Birth Certificate File** for the 5-year period 1989 through 1993. Census data for 1990 related to the zip code of maternal residence were extracted from the Improved Pregnancy Outcome Data Management System.⁵

California is divided into 11 regions for the planning of maternal and child health services. Nine of these are **geographically based**, whereas the last two are service areas for the large, nonprofit HMO, Kaiser. Because deliveries among Kaiser-insured patients during the study period were generally restricted to non-Level 1, Kaiser-owned hospitals, **the Kaiser population** was excluded from the analysis. **The sample for this analysis (N = 24,094) consisted of all live-born, 500- to 1499-gm VLBW infants delivered in nonmilitary hospitals located in one of California's nine geographic perinatal regions during 1989 through 1993.**

The hospital of birth was determined from the California birth certificate. Classification as Level I (without a NICU) or Non-Level 1 was based on the State of California's Office of Statewide Health Planning and Development Annual Report of Hospitals for 1989 through 1993.

The sociodemographic characteristics of the mother that were examined included race, age, and educational status. Aspects of the pregnancy history included the adequacy of **prenatal care**, **parity**, **prior infant** deaths, and complications of the current pregnancy. Prenatal care was assessed as adequate, intermediate, or inadequate, using the Kessner index.¹¹ The sociodemographic and pregnancy history factors were selected because of their association with reduced access to health care.¹¹⁻¹³ They were obtained from the birth certificate.

The geographical variables examined were: perinatal region, as determined from the birth certificate, the level of urbanization of

maternal residential zip code, determined from the 1990 census, and the distance to the nearest hospital with a NICU. Distance to hospital is known to be a strong predictor of hospital choice.^{14,19,20,22} Distance to hospital was estimated by the distance from the centroid of the zip code of maternal residence to the centroid of the zip code of the nearest hospital with a NICU. The intercentroid distances were determined from a geographic file developed by Ciaran Phibbs et al.¹⁰ Nongeographic zip codes (such as postal delivery boxes that are common to both inner urban and rural areas) and nonvalid zip codes were coded as missing.

Multivariate logistic analyses were performed with the SAS computer program proc Gen Mod.¹⁴ For each variable considered, the adjusted odds ratio approximates the independent relative risk of **VLBW delivery at a Level I hospital taking all variables included in the model** into consideration. For example, an adjusted odds ratio of 1.20 indicates a 20% increase and an odds ratio of 0.80 a 20% decrease in the likelihood of delivery at a Level I hospital when compared with the **reference category, which is assigned an odds ratio of 1.00**. Odds ratios cited in the text, are always adjusted to take into account the effects of **all the variables included in the analytic model** (see **Table 2 for variables and their categorization**). The terms "increased" or "decreased" are only used when $p < 0.05$ (two-sided). **In addition to the full cohort, analyses were conducted for women who lived within 2.5 miles of a NICU.** Separate analyses were also performed for white non-Hispanic, Hispanic, African American, and Asian mothers as self-identified on the birth certificate.

RESULTS

During the period 1989 through 1993, there were 2,596,924 live births to **California residents born in the 270 nonmilitary hospitals with perinatal services in California's nine geographic perinatal regions**. Of these births, 24,094 or 0.93% were VLBW. **For the state as a whole, only 10.5% of these VLBW infants were born at hospitals without a NICU. However, across the nine perinatal regions, the percentage of VLBW infants delivered at Level I hospitals ranged from 3.1% to 24.27% (Table 1).**

Table 2 shows the results of a logistic regression model used to identify factors associated with the risk of delivering a VLBW at a Level I hospital. The sociodemographic characteristics of the mother that were associated **with Level I hospital delivery included race, maternal age, and education**. Compared with white mothers, both **African American and South East Asian mothers** were 40% less likely to deliver a VLBW infant at a Level I facility (adjusted odds ratios of 0.60 and 0.58, respectively). Hispanic women were 16% more likely to deliver at a Level I hospital. Because women of color often reside in inner-city neighborhoods that are relatively close to large public hospitals that are infrequently Level 1, residential proximity to a higher level hospital may contribute to these findings. To explore this possibility, the analysis was restricted to mothers who lived within 2.5 miles of a NICU. Compared with white women, African American and South East Asians who lived within 2.5 miles of a NICU were still less likely to

Table 1 Delivery Location for Total and VLBW Births in California's Perinatal Regions, 1989 through 1993

Perinatal Region	Adjusted odds ratio* for level 1 t VL13W births	Total regional births	Percent births in Level 1 e/o) births in Level 1 ~./.)	Regional VLBW Percentage of VLBW Level births in Level 1 (%)	Level 1 hospitals per year	NICUt Ratio of Level 1 to hospitals per NICU year		
San Diego/Imperial	0.37T	217,917	9.20	1858	3.34	5.4	10.2	0.53
North Coast	0.43T	113,680	17.43	1253	3.11	11	12	0.92
Mid-Coast	0.99	205,595	16.67	1608	7.52	7	15	0.47
Los Angeles§	1.00	993,239	25.53	9789	7.08	47.4	40.8	1.16
Inland County	1.52t	223,085	41A	2234	14.41	16.6	8	2.08
Orange County	1.77~	254,103	31.97	1783	11.78	12.8	10.6	1.21
East Bay Region	1.86t	119,939	32.81	1326	10.33	9	7.4	1.22
Northeast	2.67t	215,787	49.31	1882	20.09	22	8	2.75
San Joaquin Valley	2.75t	253,579	43.06	236i	24.27	20.2	6.2	3.26
Total		2,596,924	29.09	24,094	10.52	151.4	118.2	1.28

*Based on a logistic model controlling for the effects of race/ethnicity, education, mother's age, adequacy of prenatal care, prior birth history, payer source, and proximity to NICU hospital. Data from State of California Linked Birth/Death Cohort files 1989 through 1993.

†As reported by the California Office of Statewide Healthcare Planning and Development (OSHPD).

~V < 0.05.

§Includes Santa Barbara and Ventura Counties.

deliver at a Level I facility (adjusted odds ratios of 0.60 and 0.65, respectively). However, Hispanic women living within 2.5 miles of a NICU did not have a statistically significant ($p < 0.05$) increase in delivering at a Level I hospital (odds ratio 1.16, $p = 0.14$).

Maternal age and level of **education were both important** predictors of delivery site. Compared with women aged 20 to 34 years, teenagers were approximately 20% to 30% more likely while women over 34 were 30% to 35% less likely to deliver a VLBW infant at a hospital without a NICU (Table 2). Women who had completed college were 35% less likely to deliver a VLBW infant in a Level I hospital than women who had completed high school.

The effects of pregnancy-related factors were also analyzed. Although parity was not predictive, suboptimal prenatal care, complications of the present pregnancy, and a history of two or more prior neonatal deaths were important predictors. As would be expected, the likelihood of a VLBW birth at a Level I hospital was increased in women with inadequate prenatal care (no, unknown, or only third trimester) and decreased in women with two or more complications of pregnancy. An important **unanticipated finding** was a 70% increase in the likelihood of VLBW delivery at a Level I hospital in the 162 women who had experienced two or more prior infant deaths. In this subset it was possible that the abrupt onset of premature labor may have necessitated delivery at the nearest hospital rather than the nearest hospital with a NICU. To explore **this possibility**, we examined the location of delivery for 98 women with two or more previous infant deaths who lived within 2.5 miles of a NICU. Taking all other factors into consideration, women with two or more previous infant deaths who lived within 2.5 miles of a NICU still had an increased likelihood of utilizing an inappropriate delivery site (odds ratio = 2.24, $p = 0.008$). Race-specific analyses (Table 3) indicated that controlling for distance to the nearest

NICU, the association between two or more infant deaths and Level I VLBW delivery was observed only in Hispanic women.

Several payer sources were associated with the site of VLBW delivery (Table 2). Compared with women with private insurance, women who are classified as self-pay were 53% more likely to deliver their VLBW infant at a Level I hospital. However, women whose delivery was paid for by Medi-Cal (California Medicaid) insurance were 24% less likely to have a VLBW delivery at a Level I hospital. A potential explanation for this association is that a significant portion of the Medi-Cal-insured women live in inner-city areas, near large public hospitals with NICUs. **inclusion of distance to the nearest NICU should have controlled for this possibility.** As an additional check, we **examined the subcohort of women who lived within 2.5 miles of a NICU.** Payer status remained an important predictor. Even for women living close to a NICU, the likelihood of inappropriate delivery was decreased in Medi-Cal deliveries (odds ratio = 0.70) and increased for self-pay (odds ratio 1.63). It is important to note that the self-pay group includes both uninsured and medically indigent mothers.

Our analysis confirms that distance to a hospital with a NICU is an important predictor of delivery location. "Compared with mothers **who live within 2.5 miles of a NICU, the odds ratio for VLBW delivery** at a Level I hospital are increased to 1.64 for women who live 5 to 24 miles and to 3.97 for women who live at least 25 miles from a NICU (Table 2).

A second geographic measure that we examined was the rurality of maternal zip code as determined from the 1990 census. As compared with zip codes that are more than 75% urban, women who reside in locations that are 50% to 75% urban have a 99% increase in the likelihood of inappropriate site of VLBW delivery (Table 2). It is of note that the risk for inappropriate delivery site was not increased for

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Table 2 The Impact of Sociodemographic, Perinatal, and Geographic Factors on VLBW At Non-NICU Hospitals

Category	VLBW	% in category	% VLBW births at Level I hospitals	Adjusted odds ratio	Confidence interval
Maternal race					
African American	4,407	18.2	6.8	0.65	(0.56, 0.76)*
Hispanic	9,886	41.0	11.5	1.16	(1.04, 1.30)*
Native American	110	0.4	5.5	1.26	(0.73, 2.20)
Other Asian	612	2.5	10.1	1.16	(0.86, 1.52)
Other race	870	3.6	9.1	1.00	(0.78, 1.29)
South East Asian	435	1.8	6.4	0.64	(0.43, 0.95)*
White	7,774	32.2	11.7	1.00	
Maternal age (yr)					
0-18	1,604	6.6	13.3	1.23	(1.03, 1.47)*
18-19	1,945	8.1	16.6	1.31	(1.13, 1.53)*
35-39	2,865	11.9	7.2	0.70	(0.60, 0.82)*
≥40	702	2.9	6.8	0.65	(0.48, 0.89)*
Unknown	17	0.1	17.7	1.17	(0.28, 4.93)
20-34	16,961	70.4	10.5	1.00	
Maternal education					
<High school	9,106	37.7	11.5	0.95	(0.85, 1.06)
Some college	4,310	17.8	9.8	0.91	(0.80, 1.04)
College	2,805	11.6	6.4	0.65	(0.54, 0.78)*
Unknown	374	1.6	13.3	1.10	(0.77, 1.59)
High school	7,499	31.1	11.1	1.00	
Parity					
1	9,401	39.1	10.6	0.97	(0.88, 1.07)
2-5	13,415	55.7	10.4	1.00	
≥6	1,140	4.7	11.3	1.03	(0.83, 1.27)
Unknown	123	0.5	13.8	5.14	(0.61, 43.12)
Kessner index					
Inadequate	2,350	9.7	11.3	1.20	(1.02, 1.40)*
Intermediate	8,508	35.3	12.3	1.33	(1.21, 1.47)*
Adequate	13,236	54.9	9.3	1.00	
Pregnancy complications					
0	5,346	22.2	9.5	1.00	
1	5,702	23.7	12.0	1.09	(0.96, 1.24)
≥2	8,263	34.3	10.2	0.88	(0.78, 1.00)*
Unknown	4,783	19.9	10.4	0.95	(0.83, 1.09)
Previous infant death					
0	22,872	94.9	10.4	1.00	
1	912	3.8	11.8	1.18	(0.95, 1.47)
≥2	192	0.8	15.6	1.70	(1.11, 2.60)*
Unknown	118	0.5	12.7	0.22	(0.02, 2.02)
Payor source					
Medi-Cal	13,704	56.9	10.3	0.75	(0.67, 0.83)*
Self-pay	1,178	4.9	16.8	1.50	(1.24, 1.80)*
Other source	546	2.3	12.1	1.11	(0.83, 1.49)
Insured	8,666	36.0	9.9	1.00	
Urbanization					
0-50%	890	3.7	19.2	1.14	(0.94, 1.39)
50%-75%	1,047	4.4	32.4	1.99	(1.69, 2.35)*
>75%	21,534	89.4	9.0	1.00	
Unknown	623	2.6	13.5	0.90	(0.62, 1.30)
Distance to nearest NICU hospital (centroid distance in miles)					
<2.5	10,061	44.0	8.2	1.00	
2.5-5	8,557	35.5	8.1	0.96	(0.86, 1.07)
5-10	3,468	14.4	18.5	1.63	(1.44, 1.85)*
10-24	507	2.1	16.6	1.71	(1.32, 2.23)*
25-44	451	1.9	32.2	4.04	(3.21, 5.07)*
>44	134	0.6	40.3	3.95	(2.66, 5.84)*
Unknown	371	1.5	12.4	1.70	(1.04, 2.78)*
MCH region					
San Diego/Imperial	1,858	7.7	3.3	0.37	(0.29, 0.49)*
North Coast	1,253	5.2	3.1	0.43	(0.30, 0.60)*
Mid-Coast	1,608	6.7	7.5	0.99	(0.81, 1.22)
Los Angeles	9,789	40.6	7.1	1.00	
Inland County	2,234	9.3	14.4	1.52	(1.30, 1.78)*
Orange County	1,783	7.4	11.8	1.77	(1.50, 2.10)*
East Bay	1,326	5.5	10.3	1.86	(1.52, 2.28)*
Northeast	1,882	7.8	20.1	2.67	(2.28, 3.12)*
San Joaquin Valley	2,361	9.8	24.3	2.75	(2.39, 3.17)*

Odds ratios were estimated from a logistic model, taking into account all variables listed. Confidence Intervals were estimated at a 95% confidence limit. Data are from the California Vital Statistics Birth Certificate File, 1989 through 1993. Level I Hospital = Non-NICU Hospital as defined by the California Office of Statewide Healthcare Planning and Development (OSHPD).

*P < 0.05.

Factor	Full model	African American	White	Hispanic
Number of VLBW births	24,094*	4452	7774	9886.00
% Vlbw births	10-52	6.8	11.7	11-50
Mother's race				
African American	0.65			
South East Asian	0.64			
White	1.00			
Hispanic	1.16			
Mother's age (yr)				
<18	1.23	1.13	1.09	1.30
18-19	1.31	1.40	0.99	1.47
20-34	1.00	1.00	1.00	1.00
35-39	0.70	0.47	0.65	0.85
-40	0.65	0.31	0.63	0.88
Mother's education				
College	0.65	0.87	0.66	0.61
High school	1.00	1.00	1.00	1.00
Kessner prenatal care				
Inadequate care	1.20	1.31	1.18	1.29
Intermediate care	1.33	1.41	1.28	1.32
Adequate care	1.00	1.00	1.00	1.00
Number of prior complications				
Two or more complications	0.88	1.15	1.08	0.77
Zero complications	1.00	1.00	1.00	1.00
Number of prior infant deaths				
Two or more fetal deaths	1.70	1.04	1.40	2.27
Zero fetal deaths	1.00	1.00	1.00	1.00
Payor source				
Medical	0.76	0.92	0.95	0.59
Selfpay/indigent	1.50	1.04	1.37	1.52
Insured	1.00	1.00	1.00	1.00
Urbanization				
50-75% urban	1.99	2.45	1.83	2.45
>75% urban	1.00	1.00	1.00	1.00
Distance to nearest maternal hospital (miles)				
<2.5	1.00	1.00	1.00	1.00
2.5-5	0.96	0.92	0.94	1.03
5-10	1.63	1.19	1.59	1.72
10-24	1.72	1.01	1.40	2.37
25-44	4.04	12.73	2.82	5.00
>44	3.95	2.30	4.03	3.53
Unknown	1.70	0.93	1.71	1.73
MCH region				
San Diego/Imperial	0.37	0.67	0.37	0.30
North Coast	0.43	0.00	0.65	0.12
Mid Coast	0.99	0.63	0.88	1.29
Los Angeles	1.00	1.00	1.00	1.00
Inland	1.52	1.54	1.30	1.66
Orange	1.77	2.41	1.41	1.68
East Bay	1.86	1.51	1.50	2.11
North East	2.67	4.92	2.60	1.79
Sanjoaquin	2.75	2.97	2.99	2.26

Bold font indicates significant ($p < 0.05$). Data from the State of California Department of Health Services Birth/Death Cohort File, 1990 through 1994.

women who reside in zip codes that are less than 50% urban. These findings persist when the analysis was restricted to women who live within 2.5 miles of a NICU. Of the 10,606 women who lived within 2.5 miles of a NICU, 201 lived in a zip code that was 50% to 75% urban. One third of these women delivered their VLBW infants at a Level I hospital (odds ratio 3.17). Although one could speculate that the availability of private transportation in very rural areas (i.e., less than 50% urban) and the relative lack of private and public transportation in zip codes that are 50% to 75% urban might underpin these findings, further studies are required.

Race/Ethnicity

The full model described several racial ethnic differences in the site of VLBW delivery. To further explore these results, separate models were developed for each of these groups. Table 3 compares the group-specific findings to those of the full model. For ease of presentation, only variables and variable categories that were found to be significant in one or more of the models were included. Significant findings ($p < 0.05$) are presented in bold print in Table 3. Full details for the four groups are available on request.

African Americans accounted for 4407 or 18.3% of the VLBW infants. Only 6.8% were born at Level I hospitals. White mothers accounted for 7774 (32.3%) and Hispanics for 9886 (41.9%) of the VLBW infants. For these groups, 11.7% and 11.5%, respectively, of their VLBW infants were born at Level I hospitals. 435 VLBW infants were South East Asian (1.81/10). Only 6.4% were born at Level I Hospitals. Because of the small number of VLBW South East Asians, the comparisons in Table 3 were limited to African Americans, whites, and Hispanics.

The full model demonstrated a gradient of risk of delivery of a VLBW infant at a Level I hospital that was highest in teens and lowest in older mothers. However, a statistically significant increased risk of Level I delivery for teenagers was only seen in Hispanic women. Conversely, decreased risk of VLBW Level I delivery for older women only reached statistical significance among African Americans and whites.

In California, completing college was associated with a decreased risk of Level I VLBW delivery. However, this was only significant ($p < 0.05$) in the white and Hispanic cohorts.

Although lack of adequate prenatal care was associated with increased VLBW Level I delivery for all three groups of mothers, the identification of two or more complications during pregnancy only reduced Level I delivery for Hispanics. It is of note that the association between two prior neonatal deaths and increased Level I VLBW delivery was also seen only in Hispanic women.

A further finding that was restricted to Hispanics was the protective effect of a delivery financed by Medi-Cal. Although self-pay increased the likelihood of delivery at a Level I facility, the association was only present for whites and Hispanics.

Geographic distance and rurality were important factors for all three subgroups. For whites and Hispanics, the negative effect of distance was first seen when the distance to the nearest NICU was 5 to 10

miles. For African Americans, there was no increase in Level I VLBW delivery until distance from the nearest NICU was 25 to 44 miles.

Health System Factors

After adjusting for sociodemographics, pregnancy-related factors, payer source, distance, and urbanization, the odds ratios for inappropriate delivery location ranged sevenfold across the nine regions (0.38 to 2.75). When the sample was restricted to only those women who lived within 2.5 miles of a NICU (to further control for geographic availability), regional variation increased (0.39 to 3.6). This suggests that regional variation was more likely to be the result of personal behavioral factors that were not examined and/or health system factors rather than local geographic considerations.

Although detailed health system characteristics were not available in our data set, it was possible to approximate the availability of Level I and NICU facilities within the perinatal regions. Table 1 shows the adjusted odds for inappropriate VLBW delivery site and the number and percentage of total infants and VLBW infants that delivered at Level I facilities. Figure 1 shows the striking relationship between the percentage of total births that delivered at a region's Level I hospitals and the region's odds of Level I VLBW delivery. It indicates that in California regionalization was least effective in those regions that had the highest percentage of total births at Level I hospitals. It is important to note that 78% of the sevenfold regional variation in the adjusted odds of Level I VLBW delivery can be accounted for by the percentage of total births that delivered at a region's Level I hospitals.

The percentage of total births delivering at Level I hospitals was weakly correlated with number of Level I ($r = 0.30$) and the number of NICU hospitals ($r = -0.29$), but highly correlated with the ratio of Level I to NICU hospitals ($r = 0.90$). Because this ratio is a proxy for the relative availability of non-NICU hospitals within a region, our finding suggests that perinatal regionalization was most compromised in those regions where the relative availability of non-NICU facilities was highest.

DISCUSSION

An important health goal for the year 2000 is to ensure that pregnant women and infants receive risk-appropriate care. The percentage of VLBW infants born at facilities without 24-hour neonatology coverage was established as a proxy to "monitor the extent to which comprehensive and coordinated mechanisms are in place to match the intensity of health care to the pregnant woman and infant's degree of risk." This indicator has great merit in that many studies have demonstrated that an inappropriate level of care at the delivery site increases VLBW morbidity and mortality.¹⁻⁶ From a population perspective, assuring an appropriate site for delivery is an important strategy for significantly improving a region's perinatal mortality.^{7,8} Although there has been a great deal of recent concern (and controversy) with respect to the effect of deregionalization on the appropriate site of delivery for VLBW infants and other neonates who require ventilation, investigations have primarily focused on the emergence of

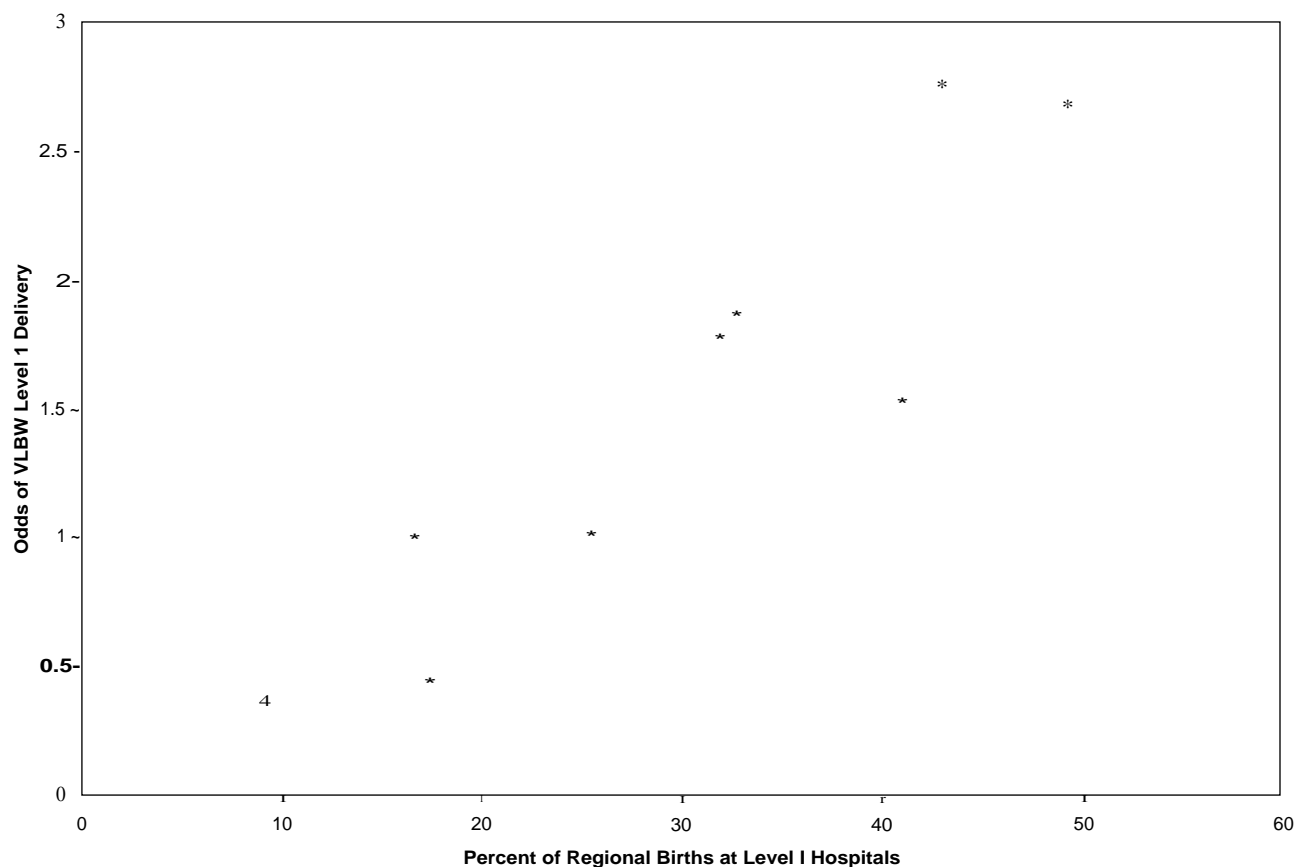


Figure 1. Percentage of total regional deliveries at Level 1 hospitals and the odds for Level 1 VLBW delivery. From a logistic regression model based on 24,904 VLBW California births from 1989 through 1993. Data were controlled for: births from race/ethnicity, age, parity, education, prenatal care, pregnancy complications, previous infant deaths, payer source, residential rurality, distance to NICU, and perinatal region. Level 1 hospitals do not include NICUs.

community-based NICUs.¹¹ The purpose of this investigation was to examine an issue about which there is little controversy: the birth of a VLBW infant at a hospital without a **NICU or 24-hour, on-call** availability of a neonatologist. Given the national goal that no more than 10% of VLBW deliveries occur at Level 1 hospitals and California's rate of 10.5% (1989 through 1993), one might ask if this study was necessary. Although the overall rate approached the national goal, a major purpose of the study was to investigate the extent of variation in Level I VLBW delivery across California's nine geographic perinatal regions. Striking differences were found. The percentage of inappropriate delivery site ranged from a low of 3.1% to a high of 24.3% (Table 1). To begin to identify factors that were associated with this variation we developed a logistic model that examined the **independent contribution of perinatal region, taking into account** sociodemographics and perinatal factors as well as distance to the nearest NICU, and residential rurality.

Our analyses confirmed the importance of distance to the nearest NICU.^{11,21} Compared with women, who live within 2.5 miles of a NICU, a 63% increase in the risk for VLBW Level 1 delivery is seen in women who live 5 to 10 miles from the nearest NICU. For women living greater than 44 miles from the nearest NICU, the risk has in-

creased 295% (Table 2). A potential limitation of our distance estimates is that they are based on the straight line distance from the **zip code centroid of maternal residence to the hospital's zip code centroid**. To control for possible errors in the precision of distance estimations, we performed a second analysis limited to women who lived within 2.5 miles of a NICU. **Controlling for sociodemographic and perinatal variables, for women who lived within 2.5 miles of a NICU there was a 10-fold difference in the risk of Level 1 VLBW delivery across the nine perinatal regions (0-31 to 3.24, details available on request).** These analyses demonstrate that decreasing the regional disparity in appropriate location for VLBW delivery represents an important challenge for California.

Review of the **sociodemographic and perinatal factors** offers suggestions with respect to areas where intervention could be important. From a **race/ethnicity perspective, inappropriate delivery was** more prevalent among whites and Hispanics than African Americans (Table 2). To investigate racial differences in risk factors for inappropriate VLBW delivery,¹⁴ specific models were developed for African Americans, whites, and Hispanics. In California, many findings of the full model were contributed in large part by the Hispanic cohort (Table 3). These include the increased risk for teenagers, women with two

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previous infant deaths, and women whose source of payment is self pay and the decreased risk in women with two or more pregnancy complications, and woman whose delivery is paid for by Medi-Cal. These findings identify important targets for intervention (Teenage Hispanics, etc). They also raise the important question as to why the positive effects of Medi-Cal-financed delivery and prenatal assessment of complications during pregnancy were limited to Hispanic women.

Common to all three racial ethnic groups were the risks of Level I VLBW delivery associated with less than adequate prenatal care. Early prenatal care provides the opportunity to identify women at risk and the time frame to establish an appropriate care plan. Early prenatal care also makes it possible to teach at-risk women how to identify the early onset of premature labor and the value of delivering at a hospital with a NICU. Also common to the three racial/ethnic groups were the risks associated with living in a zip code that is only 50% to 75% urban, and living at a distance to a hospital with a NICU.

While these findings offer some suggestions for areas of intervention, a sevenfold regional difference in the odds for inappropriate VLBW birth remained after adjusting for contributing sociodemographics and geographic risk factors. A major finding of this study is the observation that 78% of this sevenfold variation could be explained by the percentage of total births that delivered at a region's Level I hospitals. This finding emphasizes the need for a more extensive analysis of regional prenatal referral and transfer practices for high-risk pregnant women, especially in those regions where the majority of births take place at Level I hospitals. On the provider side one must understand the extent to which there is a coordinated effort between practitioners and institutions to assure that woman and infants receive a level of care that is commensurate with their level of risk. System and geographic barriers must also be identified. It is also important to evaluate patient factors. Even in the most highly organized regional systems, it is impossible to identify high-risk women who do not come in for prenatal care. It is also potentially dangerous to transfer a mother who presents in active preterm labor to a hospital with a NICU, even if it is only a few miles distant.

CONCLUSION

Decreasing the percentage of VLBW deliveries at Level I hospitals is an important health care goal for the nation. Our study demonstrates that, even when a state's overall percentage is reasonable, there may be serious differences across its perinatal regions. Although multivariate analysis based on secondary birth certificate data are an efficient way to identify the extent of regional differences and point out some of the contributing factors, its usefulness is primarily as a diagnostic tool. As one moves toward developing interventions, several qualitative strategies are worth consideration. The first is to utilize the multidisciplinary, community-based, case-review approach developed by the National Fetal and Infant Mortality Review Program.³¹ In perinatal regions that have fetal and infant mortality review programs, one could begin by identifying previously reviewed VLBW deaths of infants born at Level I hospitals. Additionally, one could establish or utilize a

fetal and infant mortality review team to review cases of VLBW infants who delivered at Level I hospitals. A complimentary approach would be to conduct focus groups of women who delivered their VLBW infants at a Level I hospital and focus groups of health care providers. Although these analyses would efficiently begin to identify the multiple factors leading to high rates of Level I VLBW deliveries, obtaining consultation from providers with low regional percentages of Level I VLBW deliveries (i.e., benchmarking) could provide insight into solutions that work.

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